Space Weather Technical Forecast

Issued on Thursday, 11 May 2023 at 01:15 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: G1-G2 Minor/Moderate geomagnetic storm conditions are likely on Day 1 (11 May), with a Slight Chance of G3/Strong storm. S1/Minor Solar Radiation Storm ongoing. Further R1/R2 Minor/Moderate radio blackouts expected.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Moderate over the past 24 hours, with an M2.2 flare observed at 10/1421UTC, originating from AR3296 (Eki/Beta-Gamma-Delta) in the northwest quadrant. There are currently eight sunspot groups on the visible disc. The largest is the aforementioned AR3296 in the northwest, which has produced several M-class flares over recent days. This is the most magnetically complex region on the disc, with Eki/Beta-Gamma-Delta configuration, with a 'delta' spot located within its intermediate portion. This region was the source of the M4.2 flare late on the 9th May, which subsequently produced a large full halo CME observed in SOHO/LASCO coronagraph imagery. This has been analysed and is Earth-directed, with a likely arrival on Day 1 (11 May), probably late in the day. AR3297 to the east of AR3296 is the second largest region on the disc, although appears to be simplifying with some decay over the last 12 hours or so. The remaining sunspots on the disc appear to be relatively small and mostly stable. No other Earth-directed have been observed.

Solar Wind / Geomagnetic Activity: The solar wind, as recorded by ACE at L1, have been at Elevated to Strong levels, with a peak speed of 714km/s observed at 10/0902UTC, due to on-going effects of the CME which arrived late on the 9th May. The solar wind density started the period above the average, with a peak of 39 ppcc observed at 10/0235UTC, before a gradual decline to the current below average values. The IMF started the period Strong, with a peak of 20nT observed at 10/0200UTC, gradually declining to the current weak levels. The all important north-south component was mostly positive, with peak values of between of +20/-10nT. The resultant geomagnetic activity was Unsettled to Active (Kp3-4), with a G1/Minor Storm (Kp5) interval observed at 10/0300-0600UTC, declining to mostly Quiet (Kp 2) at present.

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV), as measured at GOES16, has been above the S1 threshold over the past 24 hours, with a peak of 83pfu at 10/1250UTC and is currently on a steady decline. High energy electron flux (greater than 2MeV), as measured at GOES16, has been at Background to Moderate levels. The 24-hour integrated fluence has been well below Active levels. At 11/0000UTC 6.7e6 integrated pfu was recorded.

Four-Day Space Weather Forecast Summary

Solar Activity: Moderate to High solar activity is likely to continue, with further M-flares likely and a slight chance of isolated X-class flares, mostly from AR3296 or AR3297 in the northwest, as they both continue to rotate closer to the western limb in the coming days.

Solar Wind / Geomagnetic Activity: A full halo CME was observed in coronagraph imagery late on the 9th May, which was associated with an M4.2 flare originating from AR3296 in the

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northwest quadrant. The CME has been analysed and modelled, which suggests a direct hit at Earth on Day 1 (11 May), probably late in the day, although with some uncertainty. Earth is currently experiencing Strong solar winds, due to the effects of a CME, which arrived at Earth late on the 9th May. Solar winds are likely to remain strong or elevated during the coming days, due to the onset of the full halo CME. Geomagnetic activity is likely to be Quiet initially, before an enhancement to Unsettled or Active levels during Day 1 (11 May), increasing to G1-G2 Minor/Moderate Storm, probably late in the day, with a Slight Chance of a G3/Strong Storm. The effects of the CME are likely to persist into Days 2 and 3 (12-13 May), before waning into day 4 (14 May).

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is likely to remain above the S1 threshold during Day 1 (11 May) before gradually declining to background levels - unless any further significant flares occur from AR3296 as it nears the western limb in the coming days. Protons may remain enhanced due to the onset of the CME from the 9th May, although uncertain. High energy (greater than 2MeV) electron flux is expected to persist at normal background to moderate levels, with a possibility of reaching diurnally high levels on 11 May ahead of the anticipated CME arrival late on 11 May. The associated 24-hour fluence is forecast to persist below the Active threshold.

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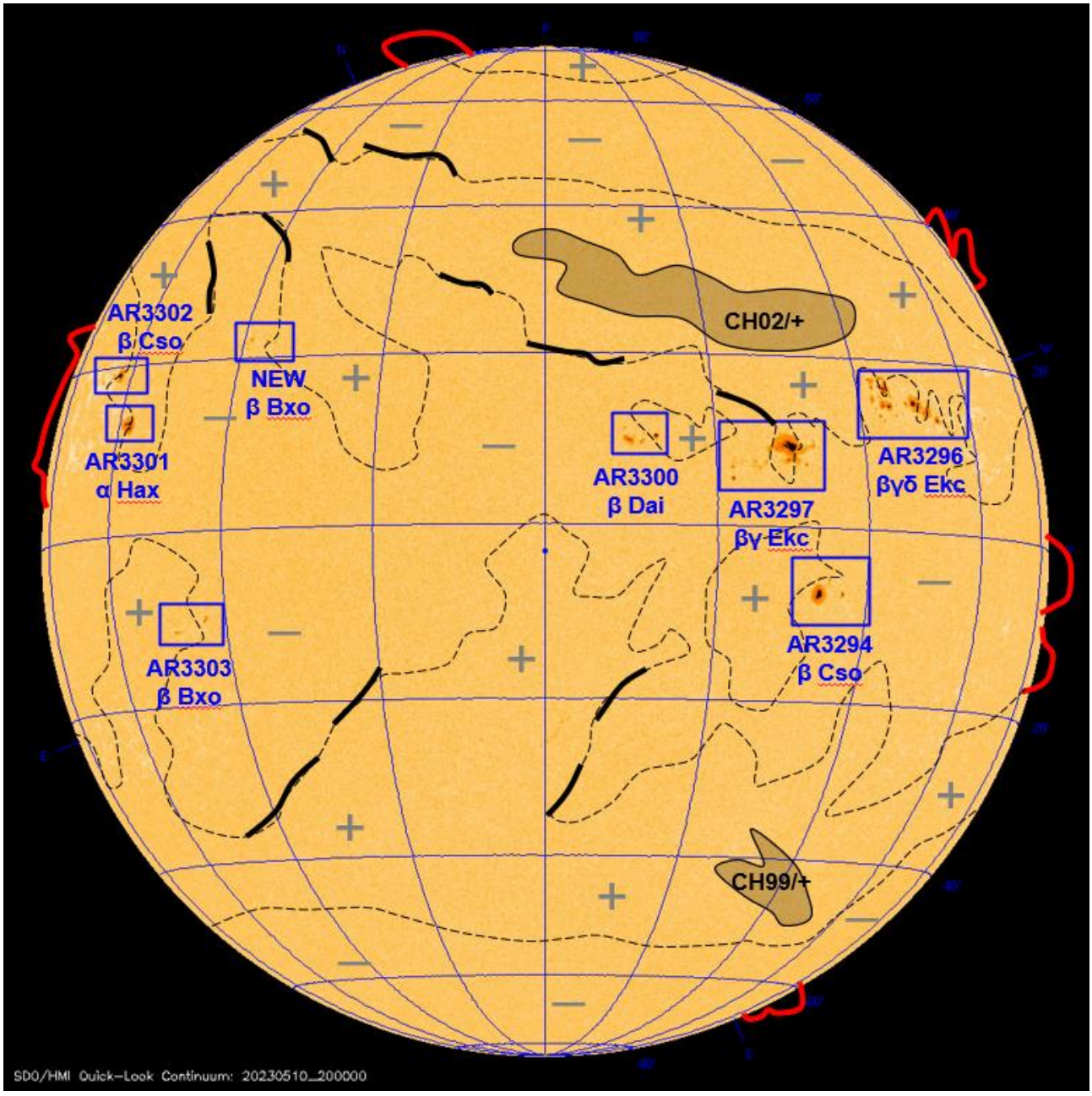
Figure 1. Solar Analysis Valid 10/2000 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

A full halo CME and shock was observed in coronagraph imagery late on the 9th May, which was associated with an M4.2 flare originating from AR3296 in the northwest quadrant. The CME has been analysed and modelled, which suggests a direct hit at Earth on Day 1 (11 May), probably arriving late in the day (from 1800 UTC), although with some uncertainty.

Geomagnetic activity is expected to be Quiet initially, before increasing to Unsettled or Active (Kp3-4) intervals, with a G1-G2/Minor-Moderate Storm (Kp5) likely late on Day 1 (11 May) and into Day 2 (12 May), with a Slight Chance of a G3/Strong Storm (Kp7).

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	Yes	60	40	10	5
Strong	G3	No	10	10	5	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
09/2100	Full Halo	AR3296	NW	1450 km/s	11/1800 UTC	Associated with M4.2 flare from AR3296 Shock expected

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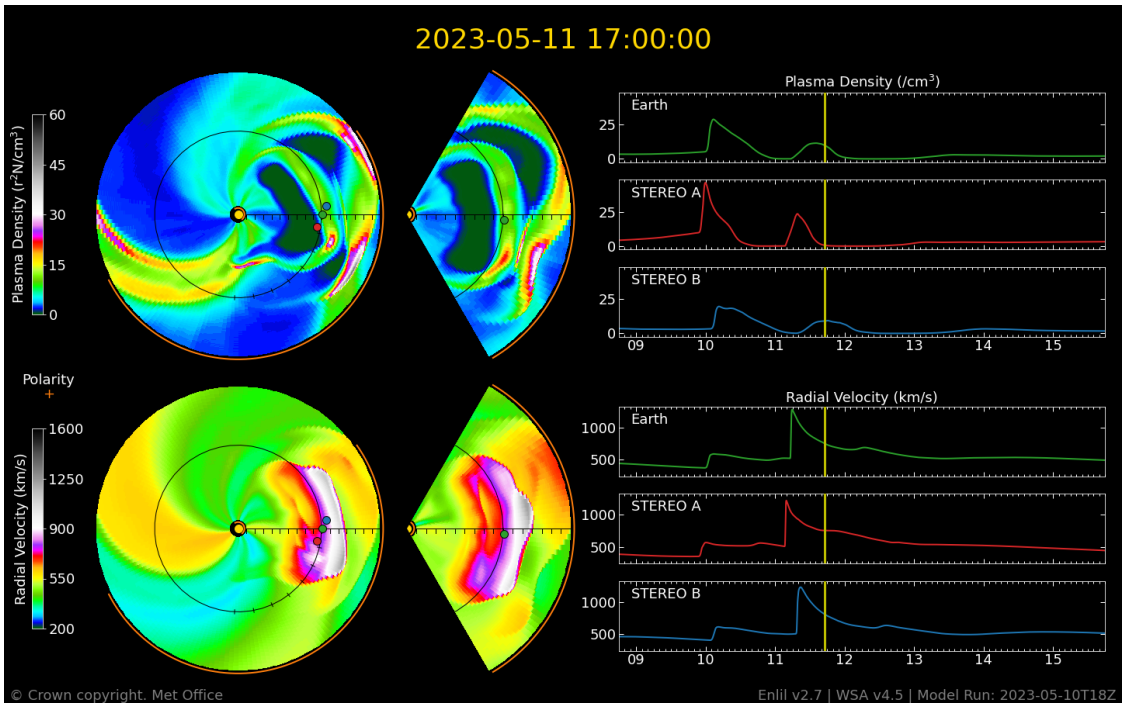
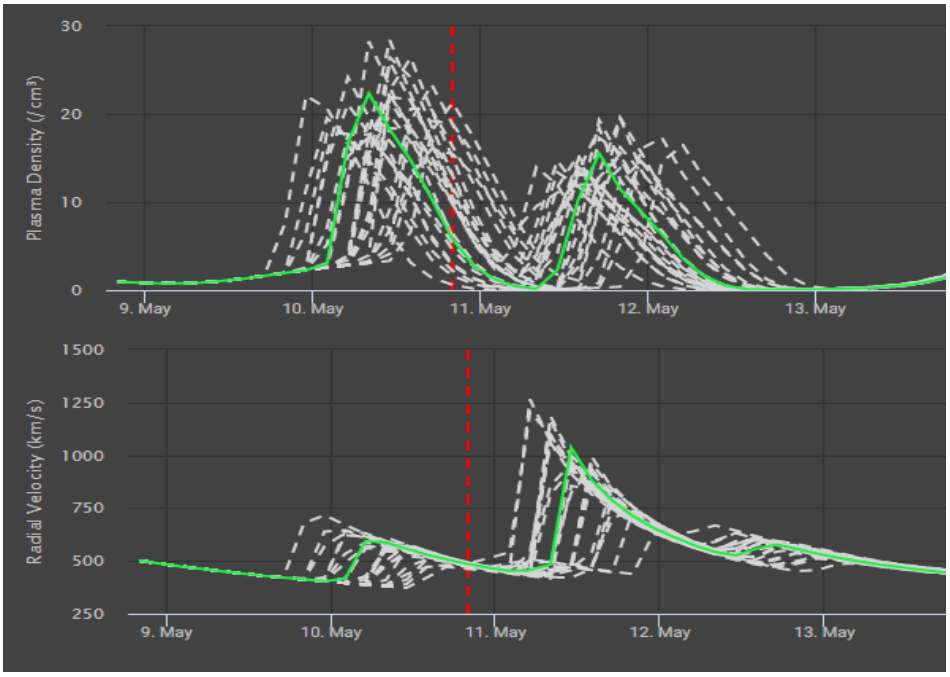
Figure 2: MOSWOC ENLIL (top) shows CME arriving on Day 1 (11 May) although probably considered too fast and is likely to arrive later in the day – around 1800 UTC – although with some uncertainty, which can be seen in the ensemble spread (bottom).





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Radio Blackouts - X-Ray Flares:

There are currently eight sunspot regions on the visible disc. AR3296 (Ekc/Beta-Gamma-Delta) in the northwest remains the most notable and magnetically complex sunspot group, which consists of a 'delta' spot within its intermediate portion. AR3297 (Ekc/Beta-Gamma) is the second largest region on the disc, which has shown some signs of decay. Most of the other remaining regions on the disc are relatively small and stable. Further M-flares are likely with a slight chance of an isolated X-class flare.

X Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	R1-R2 M Class	Yes	80	60	40	30
Very Active	R3 to R5 X Class	No	20	20	10	10

Figure 3: HMI-magnetogram (left) and HMI-intensitygram (right) shows the largest sunspot regions AR3296 and AR3297, with AR3296 containing a 'delta' spot within its intermediate portion.

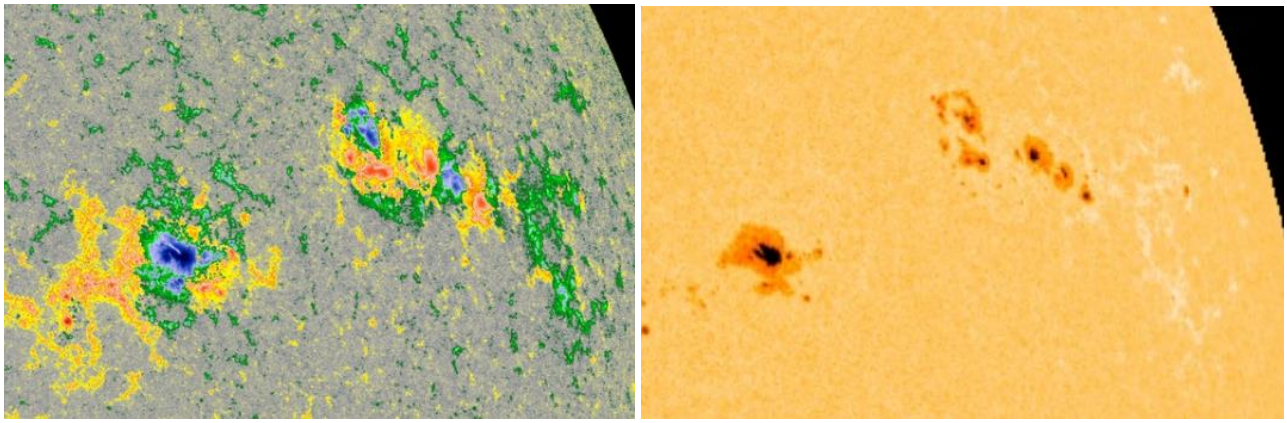

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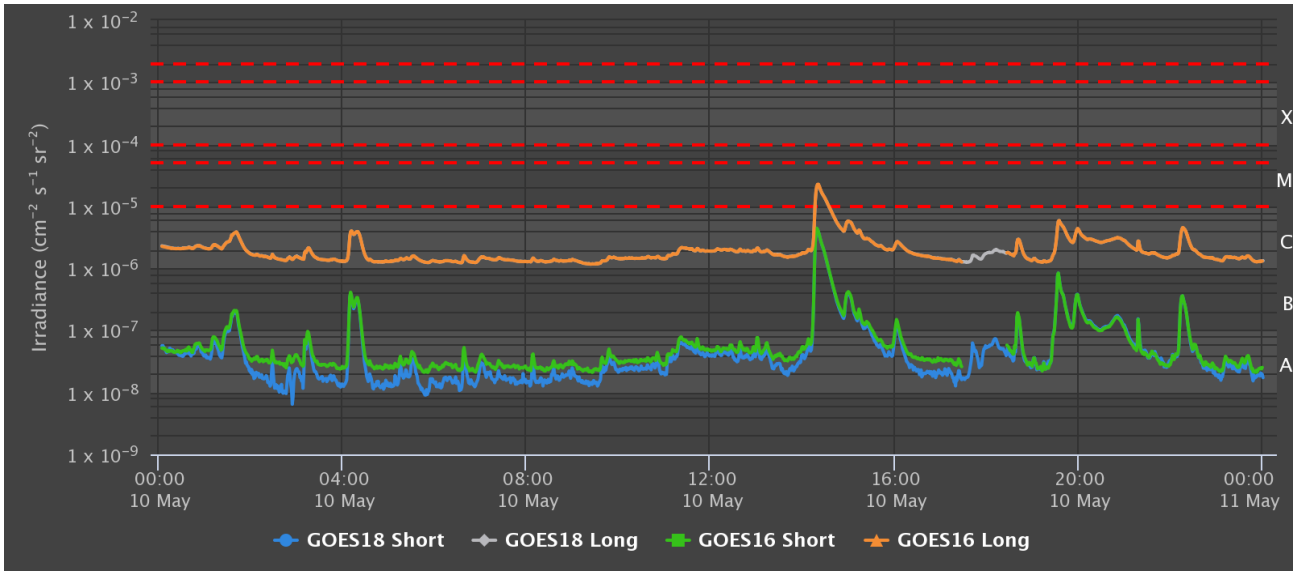
Figure 4: GOES X-Ray flares



Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux, as observed by GOES16 is currently above the S1/Minor Storm threshold in response to recent flare activity from AR3296 and weak CME influence. Protons are expected to remain above the S1 threshold on days 1 and 2 (11-12 May), with a Chance of staying above the threshold on Days 3 and 4 (13-14 May) if any further significant flares occur from AR3296 or AR3297 as they rotate closer to the western limb, or due to the forecast CME arrival on Day 1 (11 May).

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	Yes	90	70	50	50
Very Active	**≥ S3 ***	No	5	1	1	1

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)

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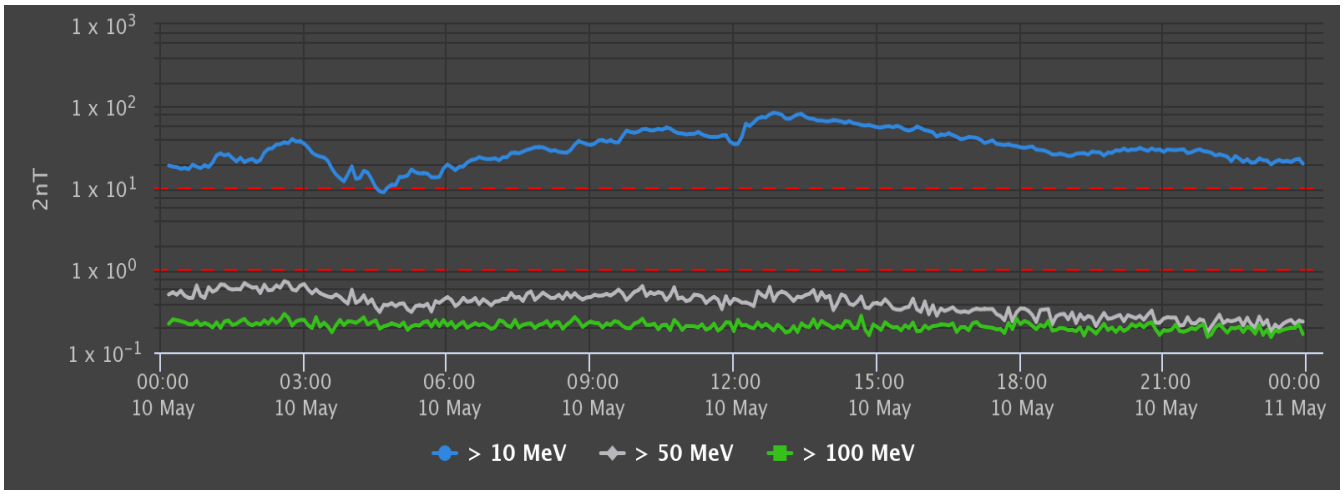
Figure 5: GOES16 Proton Flux – shows the current S1 minor storm at 10 MeV.



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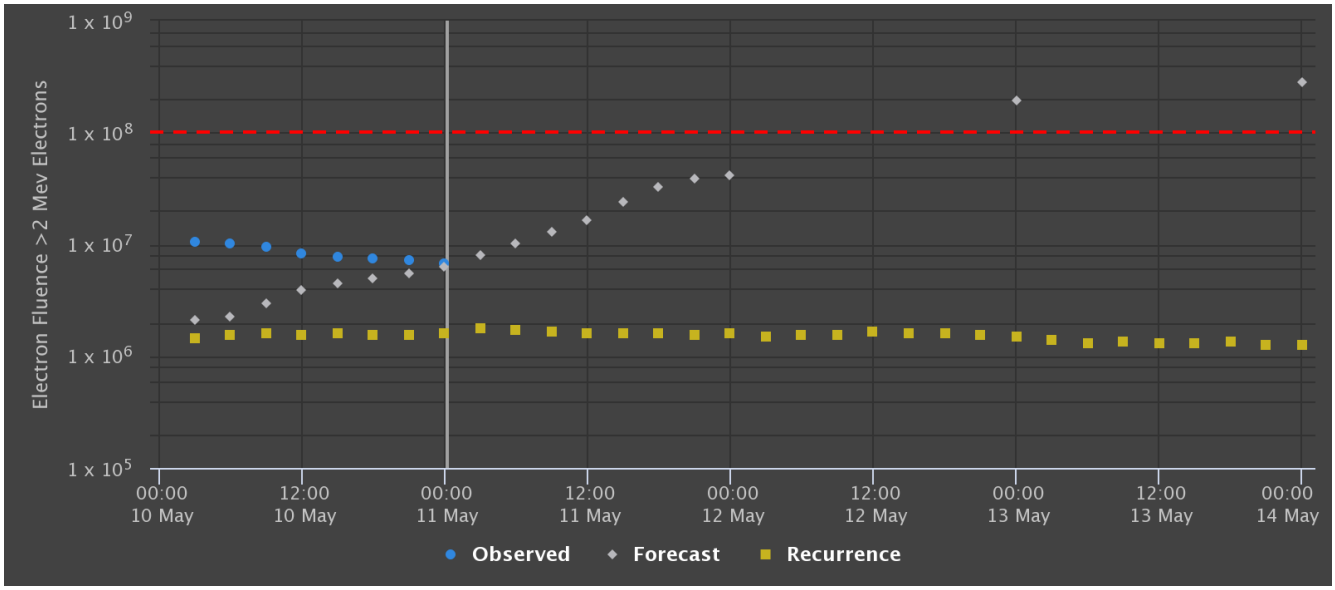
High Energy Electrons Event (≥ 2MeV):
High energy electron flux (greater than 2MeV) observed by GOES16 is expected to persist at normal background to moderate levels during this period. Electrons should remain suppressed due to the expected arrival of a CME on Day 1 (11 May). Electron Fluence is expected to remain below the active threshold throughout.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	10	1	1	1
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

Figure 6: REFM Electron Fluence – Observations and forecast



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